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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

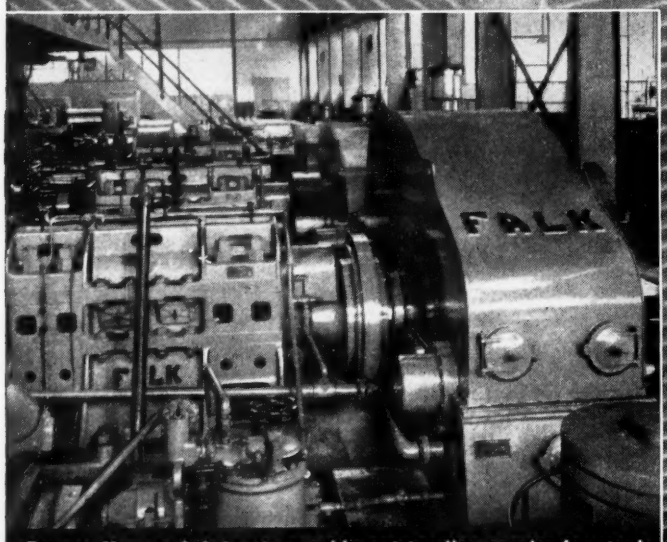
THIS ISSUE

Increasing Steel Mill Production by Protective Lubrication

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

GEAR DRIVE PROTECTION FOR

Ultra Load



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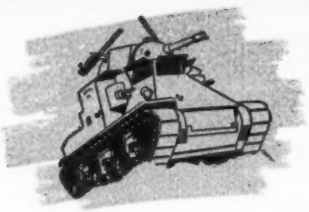

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TEXACO Lubricants

FOR THE STEEL INDUSTRY

LUBRICATION

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Increasing Steel Mill Production by Protective Lubrication

ROLLING flat steel products at an operating speed of 3300 feet per minute . . . Producing finished shell forgings, pierced and drawn by the "one-shot" press in a single operation . . . Perfecting ductile steel sheets which can be stretched to twice their area without breaking . . . Developing an annual ingot output of around 90 million tons.

These are just a few examples of the war effort of the Steel Industry—and still greater production is required, higher speeds are necessary, more operations must be combined.

Perhaps it was intuition which prompted the Petroleum Industry to anticipate these developments; perhaps the petroleum chemist was most capable of understanding the problems of the iron and steel chemist. Throughout these recent years of intensive research, both of them have had to study along parallel lines—tinkering with molecules, changing the chemical nature of alloys and hydrocarbons, making new ones out of old ones, making big ones out of little ones.

Protective lubrication of steel mill machinery was expanded along with the development of the automotive industry. Until mechanized handling of raw materials was necessary incident to the rolling of steels required for the production line, unit lubrication sufficed. The automobile changed all this. Today shipbuilding, the warplane and the tank are requiring even more drastic changes. So, the steel mill has developed a production line of its own, beyond the fondest imagination. From ore to ingot to billet to plate, this coordinated sequence, assured by lubrication, is the secret of industrial conversion to the war effort.

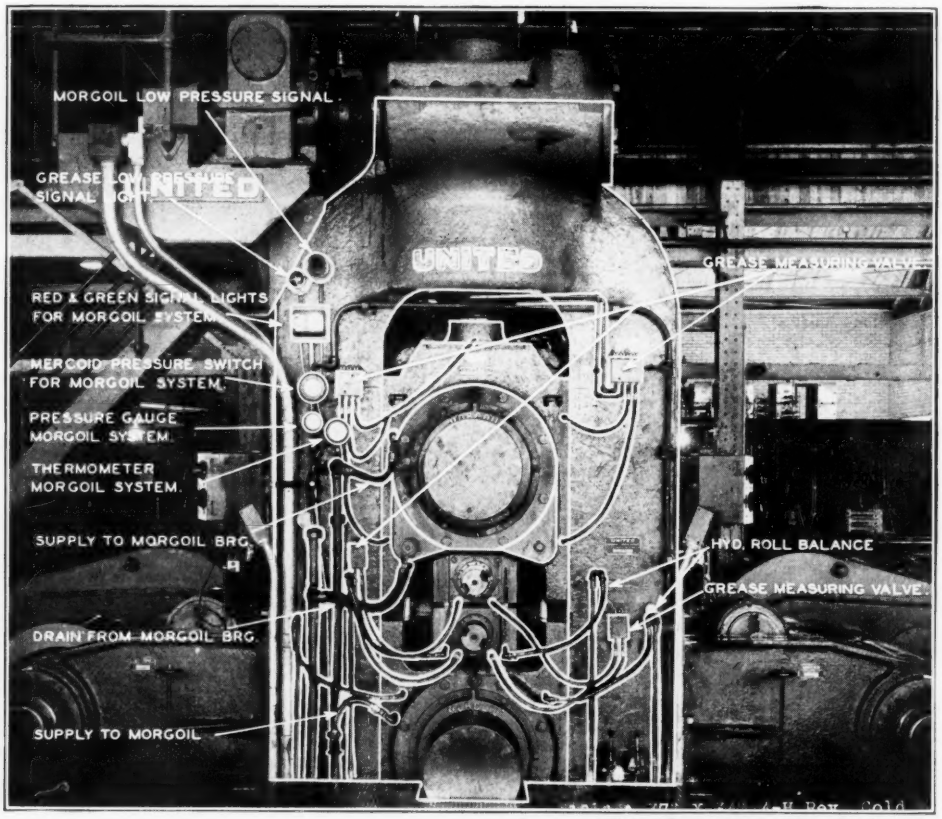
So the Petroleum Industry was prepared when the Steel Industry called for lubricating oils to protect mirror-finished roll-neck bearings worth several thousand dollars apiece; to protect gear sets designed to drive strip mills which produce steel at better than half a mile a minute. Greases also were available for the improved types of heavy duty roller bearings designed for extreme pressure conditions. Rust preventives were on hand to protect sheet steel surfaces against rust or corrosion while in the course of delivery to the war production centers.

In the design of steel mill machinery, operations have become more synchronized, clearances have been reduced, gears are today built more and more enclosed, and all other machinery in general is designed for better protection of their moving parts. Automatically, this has protected lubrication. So the possibility of contamination of oils and greases has been greatly reduced. Hence, one can study with greater confidence those specific physical or

chemical properties which must be considered in accordance with the operating conditions.

Temperature control of the oil in a circulating system has gained much consideration for this method of lubrication, with the added protection of suitable means for purification

2. The exclusion of non-lubricating foreign matter.
3. Economy of lubricants.
4. Greater availability of the mill, since equipment can be lubricated while in operation.



Courtesy of United Engineering and Foundry Company

Fig. 1—End view of a United mill showing details of the lubricating systems serving the grease-lubricated roller bearings on the work rolls, and the oil lubricated Morgoil back-up roll bearings.

or continuous filtration. This not only enables economy of lubricants but also more dependable maintenance of production schedules.

Increase in useful life of bearings and gears, reduction in maintenance and repair expense, including reduction in the labor attendant upon lubrication, have been other items which have lent an impetus to circulating oil lubrication.

CENTRALIZED LUBRICATION

Lubrication by means of centralized pressure can involve either grease or oil, according to the design of the lubricating system. The advantages of any such means of lubrication, under adequate pressure, include:

1. Positive delivery of the lubricant to insure maintenance of a sufficient film between the bearing surfaces.
5. Minimum of hazard in handling, or filling of lubricating equipment.

The adaptability of centralized control was first studied with respect to greases, for lubricants of this nature had grown up with the iron and steel industry. When roll neck bearings, table rolls, and the wide variety of other heavy duty bearings were largely exposed, heavy greases were found to be most tenacious and better able to remain adjacent to the parts to be lubricated with consequently less loss. But at best, this type of lubrication was inadequate. It was highly essential to improve this condition as far as possible, for loss of lubricant meant dripping and introduced a personal hazard which was contrary to all ideals of safety.

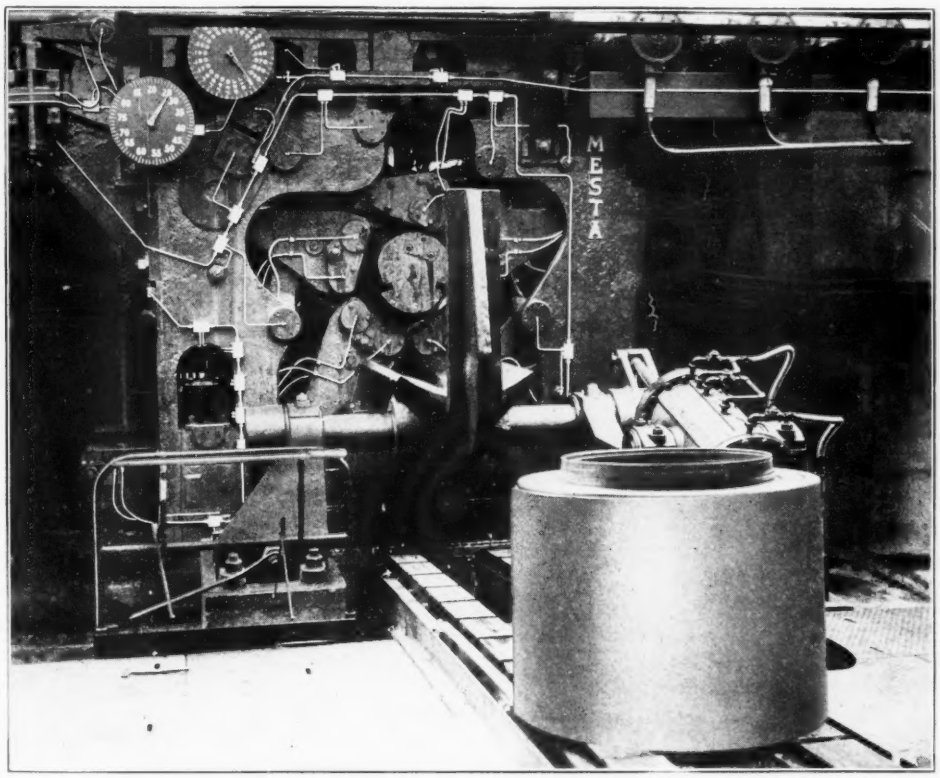
With the perfection of steel mill rolling machinery a number of ways have been de-

veloped to enable control of greases and their delivery to the various points of application. In all, power in some form or other is customarily used. Positive piston displacement types of metering valves can be employed at each point to be lubricated. In such a system either one or two lubricant supply lines can be connected to each valve according to the type of system. For heavy duty machinery, such as is encountered in the steel mill, dual lines are sometimes employed, each serving alternately to load the respective valves periodically with the right amount of lubricant, and also to discharge this to the bearings. Certain of these systems are designed to eliminate the necessity for springs, check valves or restricted port openings. Due to the fact that they operate under high pressure, any air in the system is soon exhausted by the measuring valves, and the positive delivery of a measured charge of lubricant is assured.

this time; i.e., improvement in bearing closure with marked extension of the use of roller bearings, and the use of lighter bodied greases. Both increased operating economies, the former from the viewpoint of reducing leakage and improving working conditions, the latter by reducing the amount of power required for mill operation.

Collective lubrication through manifold equipment is today regarded as preferable, and conducive to more positive and uniform distribution of the lubricant. Furthermore, direct power systems are better suited to service where comparatively high application pressures are desirable.

In the application of such products positive and complete cleaning of bearing grooves and clearance spaces at periodic intervals is of primary importance, especially where conditions of operation may be conducive to entry and accumulation of dust, dirt or other non-



Courtesy of Trabon Engineering Corp.

Fig. 2—End view of a Mesta coiler showing piping and lubricator fittings for the Trabon system of centralized grease lubrication.

When pressure application of greases was considered and later put into application, the manually operated grease gun was first used. It was simple, expedient and economical. Two other noteworthy changes which involved mill design and procedure were also made at about

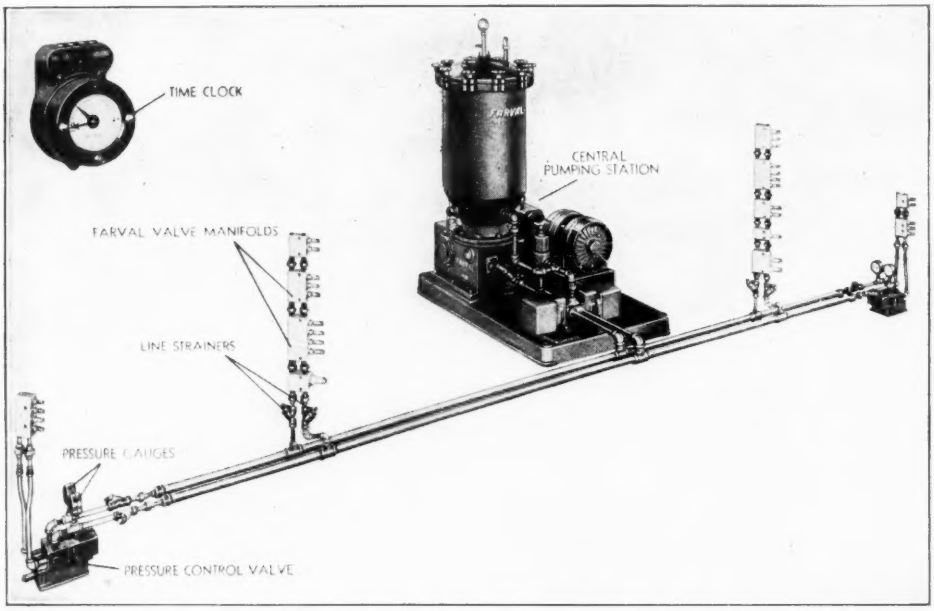
lubricating foreign matter.

The value of pressure in forcing out old grease and dirt from certain types of bearings has been definitely proved. Judgment is necessary, however, in determining when this has been completely accomplished and when to

shut off the pressure and cease forcing in new grease. If properly done, such a method of lubrication is decidedly economical. On the other hand, if the operator is careless, unobservant, or continues to apply lubricant beyond the necessary extent, he will not only waste grease but may also cause development of a sloppy condition around bearings.

The research of certain roller bearing designers has indicated that the amount of grease delivered to a bearing can be controlled by judicious installation of a suitable vent in the upper part of the housing which enables efflux of grease after a certain amount has been charged.

Concentration of pressure gun fittings at a central panel or point of control will also aid in reducing hazard and the labor essential to lubrication. This has been accomplished with such success that today not only in the steel industry, but also in other phases of production where heavy duty machinery is involved, centralized pressure grease lubrication is a practicable and comparatively economical procedure. It is distinctly advantageous in enabling reduction of hazard by concentrating equipment in a safe location, and controlling grease flow to enable the most economical lubrication.



Courtesy of The Farval Corporation

Fig. 3—The Farval automatic Dualine system of lubrication. Operating from one motor-driven central pumping unit, this system delivers lubricant to the various points via two main supply lines.

OIL CIRCULATION

Continuous circulation of oils became practicable with the application of oil-tight housings to certain types of steel mill gears, and the design of lubricating systems to serve both gears and bearings with the same oil. Installations of this type are comparable to the reduction-geared steam turbine, involving operating conditions which require oils of similar characteristics, though usually of somewhat heavier body, ranging in viscosity from around 800 to 2500 seconds Saybolt at 100 degrees Fahr.

Gear design influenced this development—improvement in tooth cutting and heat treating especially with respect to bevel units having been studied in the interest of obtaining higher speeds with reduction in wear and noise. Circulation of oils under uniform pressure conditions was found to be in line with these requirements, and helpful in reducing operating temperatures through the cooling effect of an excess of fresh cool oil.

The sleeve-type, flood lubricated bearing was also a contributing factor; its development not only focused attention upon the matter of bearing sealing but also upon the necessity for oils which would be resistant to emulsification and sludge formation. This is most important when the bearing is not sealed effectually against entry of water. Improvement of sealing media, however, has been so thoroughly worked out that water contamination today is becoming of far less concern. Even so, the characteristic of being able to separate readily from water is still an important feature, along with

the stability, or ability of the oil to resist breakdown by oxidation.

The viscosity is another very important physical characteristic for it is subject to change with change in temperature and somewhat contingent upon the operating speed. The temperature range in the modern steel mill circulating system is confined within a relatively narrow range, say between 90 and 120 degrees Fahr., with a fair average bearing temperature of around 105 degrees. The viscosity of the oil should be studied at the prevailing operating or bearing temperature.

In turn, the viscosity should vary inversely with the speed. So, in a variable speed continuous mill, where the speed of roughing is slow, a heavier oil is required than would be needed for the bearings on the finishing end which are subjected to higher rollneck speeds.

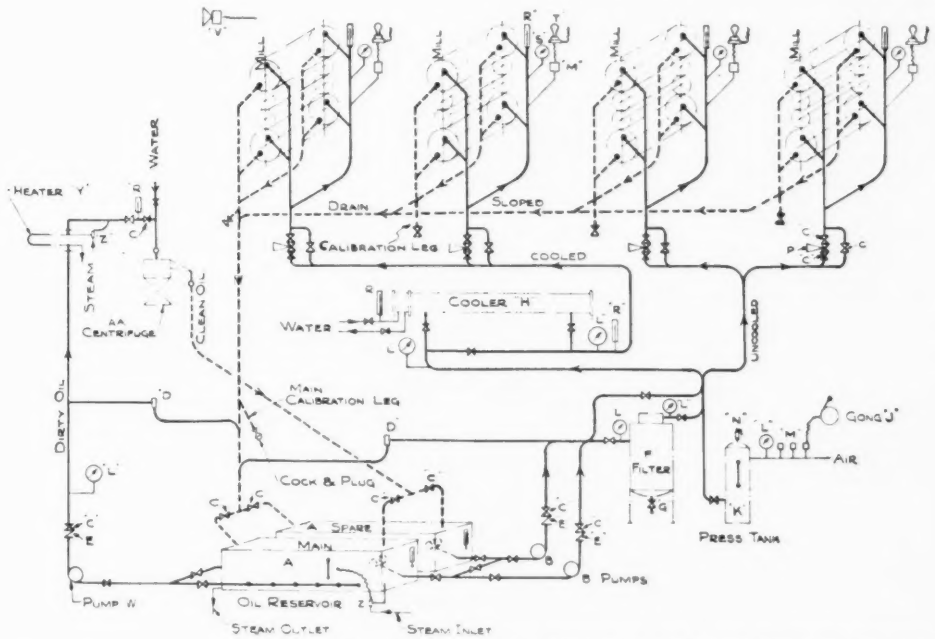
The Lubricating System

A variety of combinations have been worked out, ranging in simplicity from the unit type of gravity feed system to those completely automatic systems whereby an entire series of mill stands can be served by oil circulated under the same constant pressure. The extent to which entirely automatic operation should be approached has been widely discussed. Certain authorities feel that the unit idea whereby each unit is designed for individual lubrication will reduce the possibility of extended difficulties should faulty circulation develop anywhere in the system, or should the lubricant become contaminated.

Force-feed lubrication by gravity from an overhead tank affords a very efficient method of bearing and gear lubrication; it has been applied with equal facility to the sleeve-type roll neck bearing or the oil tight gear housing, although it is less common today on new installations. By circulating cool, clean oil under uniform pressures, from a central reservoir, to bearings and gears to provide proper lubrication and to remove heat from the friction surfaces, the life of these parts is materially increased, especially under overload and speed-up conditions.

Where gravity feed has been employed the amount of pressure available is limited. Where this may be low, due to plant conditions, it may affect the viscosity of the oil which should be used. Normally with increase in pressure, the viscosity can be somewhat reduced. This reduction in body of the lubricating film is offset by the added volume and cooling ability.

In a gravity system the supply pump delivers oil from the settling or sump tank below the operating floor to an overhead supply tank which is mounted high enough to give ample pressure to the gears and bearings. An overflow line from the overhead tank to the sump tank returns all surplus oil delivered by the pump. From this overhead tank a main supply



Courtesy of The De Laval Separator Co. and Morgan Construction Company

Fig. 4—The De Laval pressure lubrication system as designed for lubricating Morgoil bearings, showing schematic arrangement of piping and fittings for a four stand tandem continuous strip mill.

Factors Which Promote Effective Maintenance

(1) **Controlled Lubrication**—Assures positive feed of ample lubricant to protect the bearings or gear teeth.

(2) **Use of Quality Lubricants** of predetermined characteristics suited to the prevailing operating conditions.

(3) **An Efficient Oil Cooler** of ample size to cool the oil in a circulating system to the proper operating temperature.

(4) **Settling Tanks** of ample size to allow water and larger particles of foreign matter to settle out. Settling tanks reduce the load on the oil purifier and oil filters. See that oil return lines to settling tanks are below surface of oil so that excessive aeration of oil and churning can be avoided. Lines from the settling tanks should be so located as to not carry out any separated material with the oil.

(5) **Efficient Oil Filters or Centrifuges** suitably located in the system in order to remove entrained foreign matter from the oil before re-circulation.

(6) **Bearing Seals of Approved Design,** and sealing material which will not deteriorate at high temperature due to friction or when in contact with lubricants or water.

(7) **Smooth Bearing and Gear Tooth Surfaces** finished to promote maximum cushioning effect by the lubricating film.

(8) **Air Vents** to relieve back pressure on the lubricant which might cause the seal or housing to leak if the lubricant cannot expand freely with increase in temperature. Where oil is involved, back pressure may be due to small return lines.

(9) **Periodic Check of the Lubricating Systems** to insure their proper performance, and the assignment, to someone in the maintenance department, the responsibility of seeing that all equipment is adequately lubricated at the right intervals.

Factors Which May Impair Maintenance

(1) **Over-Lubrication** or use of excessive amount of lubricant, or too high pressure, may result in causing seals to leak, with subsequent loss of lubricant. Usually denoted by sloppy condition around the bearing or gear set.

(2) **Unsuitable Lubricants** which are incapable of withstanding the operating conditions—this may involve poor quality or physical characteristics unsuited to service in presence of prevailing speed, pressure, temperature or moisture.

(3) **Low Oil Cooling or Reconditioning Capacity** to cause the oil in a circulating system to be overworked or insufficiently cooled before reusage.

(4) **Settling Tanks Too Small** restricting the quantity of the oil in the system, and permitting foaming by too rapid circulation of oil. Oil return lines above the oil level permit aeration.

(5) **Careless Storage or Handling of Lubricants or Lubricating Equipment, or Inadequate Reconditioning** which may result in contamination of the lubricants by dirt or corrosive materials.

(6) **Improper Sealing,** which may permit entry of water or solid non-lubricating impurities into the lubricating system.

(7) **Irregular Surfaces of Bearing or Gears or Misalignment** of either bearings or gear teeth which will cause uneven wear, noise, interfere with lubrication and necessitate time-out for repair or correction.

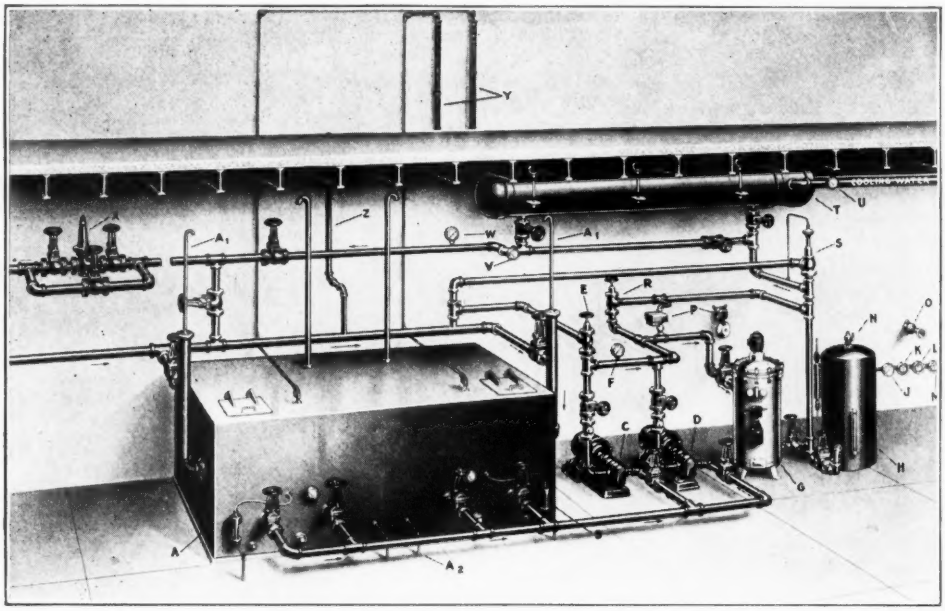
(8) **Air Pockets** in the lubricating system which interfere with complete circulation of the lubricant, especially at low temperatures, or if the oil or grease is too heavy.

(9) **Insufficient Lubrication or Overloaded Bearings,** which may result in fatigue of bearing metal, spalling, and subsequent scoring by circulation of abrasive metallic particles.

line delivers oil by gravity to the various points to be lubricated.

Full Pressure Circulation

The full pressure system uses a variable a pressure switch and light signal to warn the operator should the oil flow be interrupted. The return oil from the gears or bearings flows back to the settling tank by gravity for filtering or centrifuging, and recirculation.



Courtesy of S. F. Bowser & Co., Inc.

Fig. 5—A typical Bowser pressure oiling system showing at (A) Two Compartment (or 2 single) Tank, (A1) Vent, (A2) Steam Coil, (B) Temperature Regulating Valve, (C) Circulating Service Pump, (D) Circulating Spare Pump, (E) Relief Valve, (F) Pump Pressure Gauge, (G) Figure S22 Automatic Filter, (H) Pressure Tank, (J) System Pressure Gauge, (K) Spare Pump Pressure Switch, (L) Service Pump Pressure Switch, (M) Alarm Pressure Switch, (N) Safety Valve, (O) Low Pressure Alarm, (P) Filter Cleaning Alarm, (R) Differential Relief Valve, (S) System Control Valve, (T) Cooler, (U) Thermometer, (V) Thermometer, (W) Pressure Gauge, (X) Pressure Regulating Valve, (Y) Gallonage Indicators, (Z) Fill Pipe.

volume constant pressure pump which runs continuously and does not require a pressure tank; or a supply pump which delivers oil at a predetermined pressure from the settling tank to a pressure tank in which an air cushion is provided at the top.

Both systems require two pumps, one of which serves as a spare. The service pump cuts in automatically, by means of an electrically operated pressure switch whenever the pressure in the oil supply line drops below a predetermined minimum. Should the service pump fail or whenever the desired pressure cannot be maintained the spare pump cuts in automatically. If both pumps fail or are unable to maintain sufficient pressure, another switch which is set just below the minimum required operating pressure sets off an alarm.

Expansion of the air cushion in the pressure tank forces the oil through the main supply line and the numerous branch lines; these are equipped with orifice plates or valves to provide each bearing or gear unit with its proper share of lubricant. Frequently each of the various points of lubrication are equipped with

RELATIVE FLUIDITY

The relative fluidity of an oil is denoted by the viscosity and pour test. At low temperatures the relative fluidity becomes highly important in conjunction with the pressure available. At one time the pour test was thought to require primary consideration, especially in cold weather or under low temperature starting conditions, where the rate at which the oil would return to the settling tanks might be affected. Research has proved, however, that the viscosity must be given equal consideration. Should the oil become too sluggish at any time, flow-off from a pinion housing or bearing might be so retarded as to cause the oil to back up in the system. Furthermore, should a bearing be improperly sealed, oil might leak from the housing.

Where the viscosity or pour test are too high, the decreased fluidity and resistance to shear may also develop marked increase in power consumption.

The automatic nature of the modern oiling system calls for careful consideration to these factors of pour test and relative fluidity. With

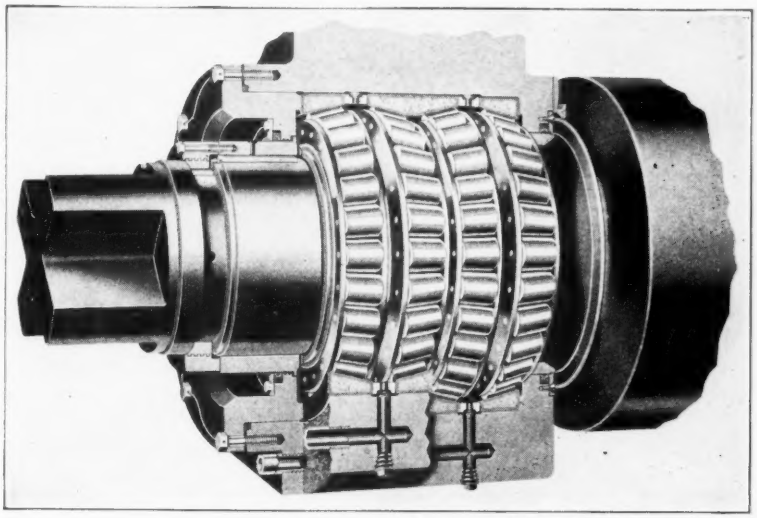
extensive piping layouts and the possibility of abnormal friction losses occurring within the system itself, reduction in oil flow may result to a sufficient degree to cause overheating of the oil in the settling tanks; also, the pumps might take more power to deliver the required amount to the moving parts and keep the oil in the supply tanks at the proper level. This will be all the more severe if the oil is exposed to oxidizing conditions and allowed to develop sludge which will increase the resistance to flow. Obviously proper steps should be taken to correct such a condition by use of a suitable oil reconditioning system. Oxidation of petroleum oils is promoted by heat, air and water; it is accelerated by the presence of certain metals, such as copper or bronze alloys.

THE DETRIMENTS OF WATER

Water contamination of any oil in a pressure circulating system is objectionable, for it may seriously impair the lubricating ability, assist the oxidation reaction and cause sludge accumulations which may retard the flow of oil through the lubricating system. Accordingly, the oil must be comparatively water-free at the beginning, and of good demulsibility; later, in service it must be kept in the same condition. It is the duty of the designing engineer to plan for a watertight system and the maintenance engineer to keep it so.

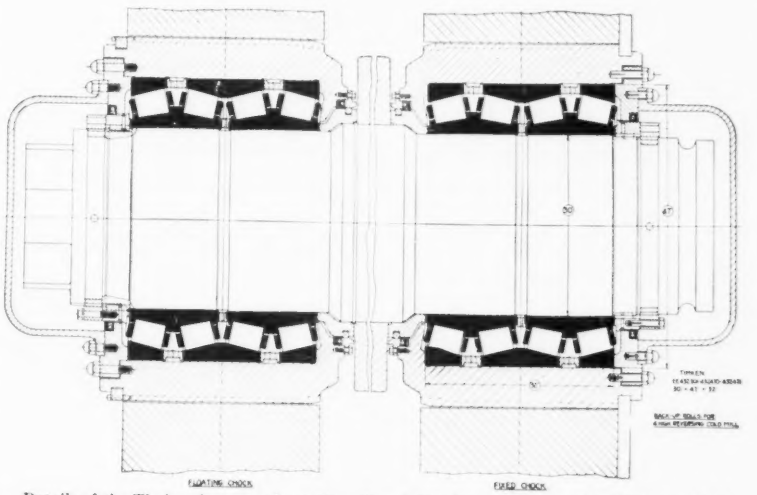
The amount of water which must be used on certain types of steel mill operations is considerable; it is one of the primary agents in heavy duty rolling mill service for cooling the rolls and reducing scale formation during rolling. Much of this water will deluge the roll neck bearings and be forced into the table bearing housings by the high pressure descaling spray. After passing over the hot metal it is dirty and may wash mill scale into parts of the lubricating system to contaminate or to react physically with any oil with which it comes in contact causing formation of permanent emulsions and sludge accumulations.

Water traps or legs as well as settling tanks aid materially in removing a considerable amount of such water before it has time to affect the oil. All points wherein water may gain entry into such a lubricating system should be carefully sealed as added insurance. With bearings, attention should be directed to their original design, in order to provide for some recognized method of sealing, which will not interfere with the free rotation of the shafts. Any binding will cause the sealing material to overheat and become worn; then water can get in and the seal becomes of little value.



Courtesy of The Timken Roller Bearing Co.

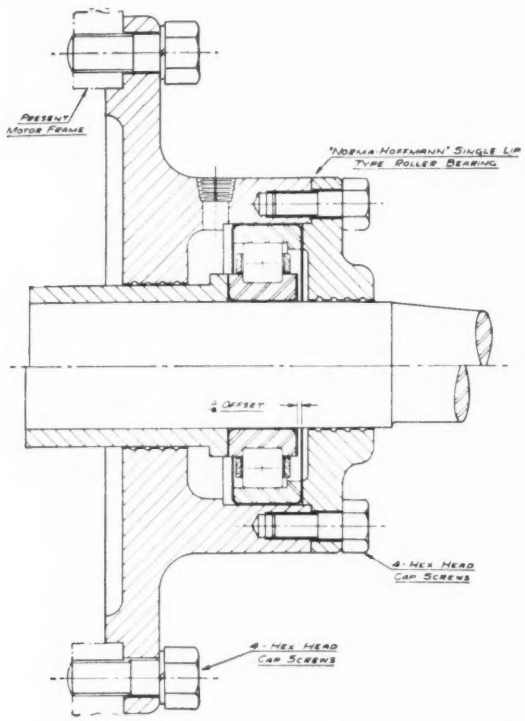
Fig. 6—Constructional details of a Timken four-row bearing of the heavy duty steel mill type designed for carrying loads prevailing on steel mill roll necks.



Details of the Timken four-row, loose fit, roll neck bearing mounting. Application of lubricant between the roll neck and the bearing cone prevents scuffing of the former.

BEARING SEALS

Bearing sealing, therefore, has been an important factor in the perfection of circulating lubrication. Experience proved that only oils of the highest quality should be used in such



Courtesy of Norma-Hoffmann Bearings Corp.

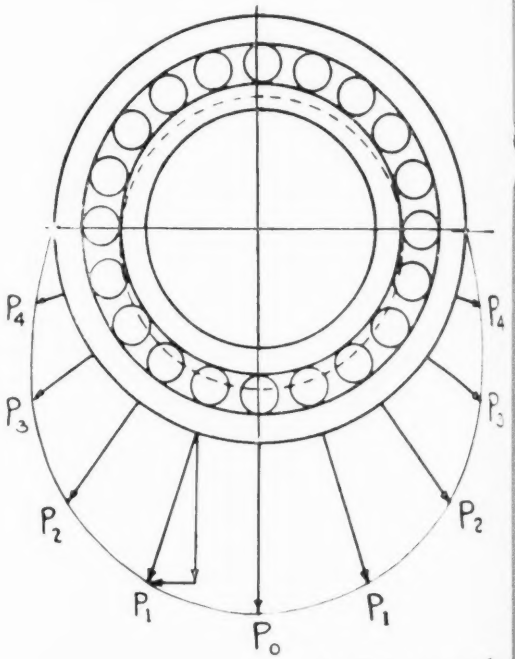
Fig. 7—Change-over design for a roller bearing flange unit for crane motors, etc. No machine work is required to make this change-over.

systems, in view of the operating conditions which involve water, speed, pressure and considerable range of temperatures. For such an oil to function effectively, however, it must be kept as clean as possible. So methods of reconditioning were studied and filtration or centrifuging equipment provided. But oil reconditioning cannot be effective if the oil becomes overloaded with non-lubricating foreign matter, or if an excess of water is present to develop even temporary emulsions. Seals, therefore, are applied at all bearings where water conditions prevail.

The operating temperature has a decided effect upon the life of certain of the sealing materials which have been used, also the extent of contact with oil. Rubber and some rubberized materials deteriorate rapidly when exposed to petroleum oil; leather or rawhide are affected by heat. Leather is insoluble in water, non-inflammable and a poor conductor of heat, but affected by dilute acids and quickly destroyed by alkalis. The amount of heat it can withstand depends upon the tanning process.

When high-speed rolling was adopted, sealing materials had to be very carefully studied. Under such conditions there may often be an increase in the amount of frictional heat developed at the point of contact between the roll neck and the sealing material. Subsequent failures of some sealing leathers and the entry of an excess of water indicated that in such cases the leathers had been exposed to excessive frictional heat, above the maximum usable temperature, caused by rubbing between the seal and roll neck.

This led to study of the applicability of certain synthetic products such as Neoprene. As this material can be used at temperatures considerably above the maximum usable temperature for leather, it has been favored as a bearing sealing material for high-speed roll neck bearings. By its ability to resist deterioration under heat, it functions most dependably as a seal and by keeping water out of the circulating system it insures the lubricating ability of the oil by reducing oxidation and sludging. At the same time the oil filtration and centrifuging equipment is able to do a better job of purification since the amount of contaminants that must be removed is reduced. As the seal must serve a double purpose, viz., retain the lubricant and exclude the water, either a



Courtesy of S. K. F. Industries, Inc.

Fig. 8—Showing the normal load distribution in a roller bearing. Note that the important load zone area extends for approximately 120 degrees. Opposite the load zone, clearance exists between the rolling elements and one race.

double seal or two separate seals must be used, i.e., a water seal and a main bearing seal.

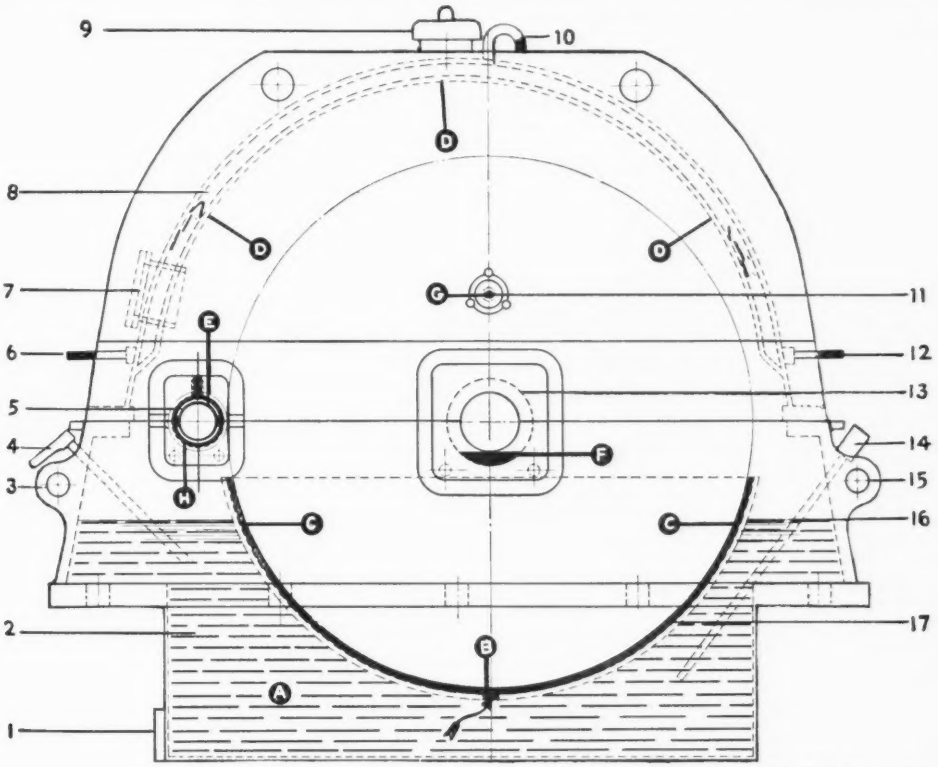
ROLLER BEARING MAINTENANCE

The economic benefits which result from a steel mill roller bearing can be measured in terms of the amount of tonnage rolled and the number of service revolutions which accumulate before overhaul is necessary. Obviously, a roller bearing can operate dependably only when the component parts are effectually protected. This means that entry of abrasive or corrosive materials must be kept out of the bearing, also that lubrication must be properly maintained.

Almost from the first installation, loading became a factor; it has continued as such, for loads have been continually increased as heavier duty machinery has been developed and equipment has been run at higher speeds. Experience was limited naturally, when the roller bearing was first applied to steel rolling mills, so proper relationship between the bearing dimensions, the load and the operating speed had to be worked out. Bearing designers have taken full advantage of the resultant data.

Function of the Extreme Pressure Grease

The modern EP grease was perfected by the petroleum industry in collaboration with certain of the bearing manufacturers to meet these overload requirements to some extent. In other words, a type of lubricant was needed which has extra load-carrying or extreme pressure characteristics. Furthermore, this grease had to be sufficiently plastic to pump readily through lengthy pipe lines of less than one inch diameter, sometimes at quite low temperatures. Added requirements of importance are stability, resistance to separation of oil from soap, sealing ability, resistance to leakage (a function of the body of the grease) and uniformity of texture. All these qualities or properties are embodied in the modern E.P. grease.



Courtesy of The Falk Corporation

Fig. 9—The patented lubricating system for the Falk type P high speed gear unit is a special development of control flood lubrication. The oil is drawn from the lubricant reservoir (A) into the inner lubrication pan (B) by the rotation of the low speed gear acting as a positive pump impeller. From the gear (C) it is directed to the water jacketed cooler (D) where it is cooled, part dropping on the gear and pinion and the balance is collected in the cover oil troughs. The troughs supply large reservoirs which feed the lubricant to the high speed bearing (E) and low speed bearing (F) under a constant pressure. Oil passing to the low speed bearing is visible through the oil sight (G). Oil passing through the high speed bearing (H) returns to the lubrication reservoir (A) as does oil from the low speed bearing.

1 Lubricant Drain; 2 Lubricant Reservoir; 3 and 15 Lifting Lugs; 4 Lubrication Control Valve; 5 High Speed Bearing; 6 and 12 Water Inlets; 7 Inspection Cover; 8 Water Jacket Cooler; 9 Air Vent; 10 Water Outlet; 11 Oil Sight; 12 and 6 Water Inlets; 13 Low Speed Bearing; 14 Lubricant Gauge Rod; 15 and 3 Lifting Lugs; 16 Oil Level; 17 Inner Lubrication Pan.

Bearing Inspection

To make sure that the maximum of service life is obtained, periodic bearing inspection is most important. Superficial inspection will indicate the bearing operating temperature, the effectiveness of the bearing seals, and the extent to which the lubricant is being retained; normally, no adjustments are made at this time since the machinery is probably in operation. Records, however, should be kept of any conditions which should be corrected at the time of roll change or over-haul.

It is fair to expect that mill overhaul will be required at fairly regular intervals, for reasons such as roll grinding, etc. Whenever the mill is shut down, the bearings should be cleaned of used grease, flushed and re-lubricated. As there is a point of maximum load on the outer race of any such bearing, it is considered good practice at this time to rotate each outer race a part turn of around 90 degrees. This will increase the life of the bearing. At the same time, the seals can be adjusted to prevent outward leakage of lubricant or inward entry of water, dirt or scale.

Preventing Neck Scoring

The difference in diameter between the bearing cone and the neck which is necessary to facilitate roll removal, causes some slippage. When this occurs, the possibility of neck scoring can be prevented by drilling through the neck in order to enable pumping grease into the clearance space between the ID of the cone and the OD of the neck. This procedure is most practicable when the mill is idle.

GEAR DESIGN

When the enclosed type of high speed mill gear set was perfected, and adapted to steel mill power transmission service, it changed materially some of the conventional ideas as to gear lubrication which had been developed on the basis of the exposed, heavy duty, slower speed, mill pinion and gear set. The transition was to a much more fluid type lubricant, designed for greater load-carrying capacity, than for adhesiveness. The responsibility of the gear designer was to develop a unit which would carry higher gear tooth loads for the same available area, thus permitting greater power-transmitting capacity with but little increase in size. The increased speed was conducive to circulated lubrication, so means for pressure circulation was built into the gear set and the housing was designed to be oil-tight. This enabled more dependable control of the oil level and rate of oil feed to the gear teeth, a factor believed to be of value in reducing noise, due to the more uniform cushioning effect of the lubricating film. This is all the more effectual when the lubricant is kept free from metallic or abrasive foreign matter.

Some noteworthy cooperative research in this regard has been carried out by the petroleum industry, the gear manufacturers and certain of the lubricating personnel in the steel industry. It has led to a coordination of ideas as to the type of lubricant best suited for the modern high-speed gear set. They have agreed that lubrication of this type of gear presents a problem entirely different from that involved with the exposed gear. To some extent it parallels the requirement of the roll-neck sleeve bearing in that circulated flood lubrication is necessary to maintain the lubricating film.

Gear tooth pressure is the dominating feature in this respect. Some gears and pinions must be designed for extreme pressure conditions; they must be lubricated by specially prepared oils of high film strength, containing selected additive materials which enable the contact surfaces of the gear teeth to carry much heavier loads without scuffing. It is a generally accepted theory that these additives owe their extreme pressure characteristics to a chemical reaction which takes place at the ooth surfaces at the time, place and temperature of contact.

During this reaction an auxiliary protective film is developed momentarily on the tooth surfaces which prevents actual metallic contact during the period of maximum load and seems to act as an anti-welding agent; otherwise, so-called welding would occur to cause scuffing. Obviously, a lubricant designed to function in this manner must be protected against contamination by water or foreign matter which would retard the desired chemical reaction or react in some other undesirable manner with the additive to impair its usefulness.

CONCLUSION

Steel production has met the challenge of defense by an offensive on its own front which has no parallel in the history of the industry. From the blast furnace to the most obscure place in the yard, improved methods of materials handling, accelerated production schedules, new ideas with regard to lubrication, have been contributing factors in the attainment of a tonnage output that would have seemed fantastic scarcely a year ago. The degree of coordinated teamwork which has resulted is equally amazing. Protective lubrication facilitates such production by extending the useful life of machinery, by relieving plant personnel for manufacturing instead of maintenance work.

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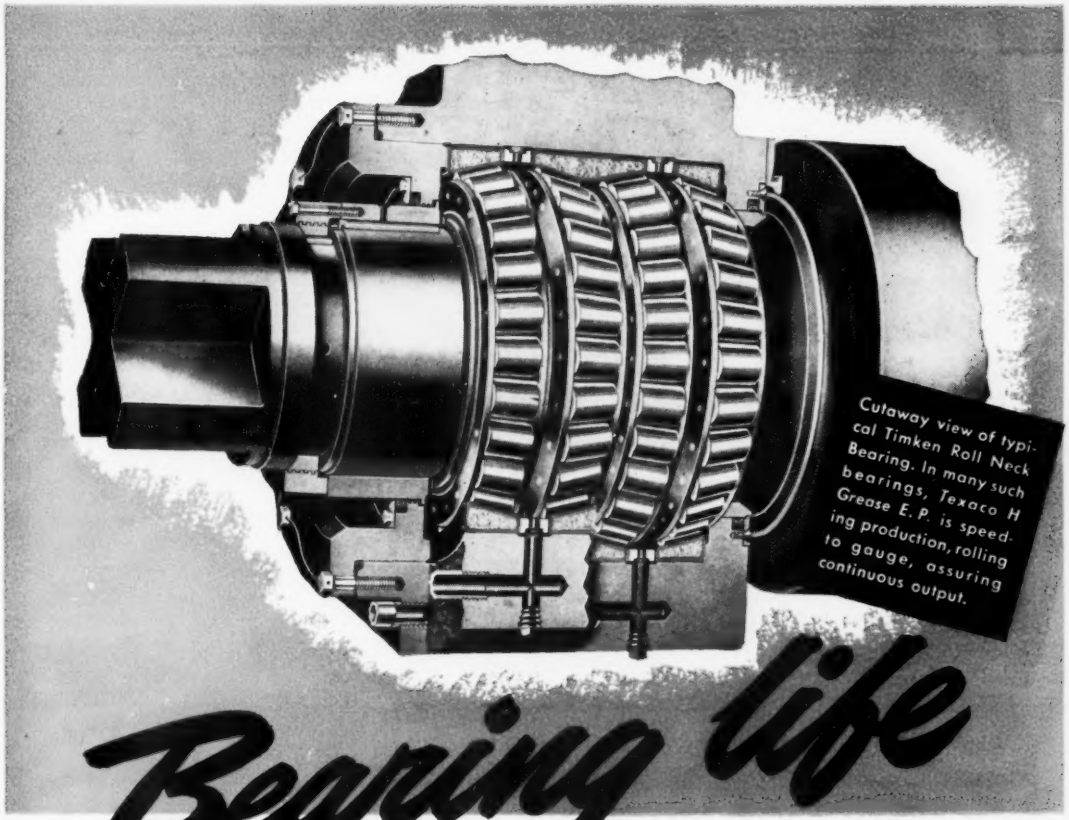
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